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EFFECT OF SULFITE AND BROMIDE CONCENTRATION ON MTF OF THE FILM

by

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ABSTRACT

The Modulation Transfer Function, the granularity and its relation to each other were investigated as functions of developer composition for a black and white sheet film. Variations in developer composition were made to examine the effects of the concentrations of sulfite and bromide independently and due to their interactions. The resulting changes for most compositions were found to be insignificant. Only one combination where bromide concentration was high and sulfite normal, resulting change was significant.

Image quality in photographic microreproduction is influenced by four characteristics of the light sensitive silver halide emulsions.

1. Sensitivity
2. Form of the H&D cutve
3. MTF
4. Granularity

For this project MTF and granularity will be explored,some background is therefore necessary. The graininess of the developed photographic image is affected by the developer composition. The final sensation of non uniformity in the image is termed graininess. The evaluation of the graininess can only be subjective and incovenient for routine measurements. A physical measurment that correlates well with the sensation of graininess is granularity. Granularity is defined as the standard deviation of the frequency distribution of density from the average.

In general the Modulation Transfer Function characterizes a film - developer system. As the frequency of the resolving power target image increases the modulation (contrast) of the imge decreases. This is the basis of the Modulation Transfer Function as applied to the film.[1]

Granularity and the Modulation Transfer Function and their relationship to each other are the two fundamental aspects [2] determining the image forming capabilities of an emulsion and hence our ability to retrieve information from the images on the film. Due to increasing light scattering within the emulsion as the image becomes smaller, modulation decreases. At the same time granularity also makes recognition of small images difficult. The two above are affected by developer composition. It is known that granularity is affected by sulfite concentration [3] which acts as the silver halide solvent. Granularity becomes smaller as the concentration of sulfite in D-76 increases from 10g/l to 200g/l. The results obtained were from a specific film-developer combination and no generalization can be made. It is also known that different MTF responses are obtained with different developers. Data was published by the Eastman Kodak and others. According to T.H. James in his book "Photographic Theory", some fine grain developers improve resolving power, all such developers however do not do so. Also the effect of the composition of the developer on the MTF is not well established. There are many factors affecting the MTF but this experiment will deal only with the effects of the developer composition. Some measure of the differences due to the chemistry may be found and possibly a new formulation of the developer to increase MTF of the film can be established. The two costituents acting as a solvent for silver halide grains and also responsible for edge effects are sulfite and bromide. These two chemicals in different concentrations will be the variable factors for the experiment. The experiment will involve exposing the film with a sine wave target and processing this film in different concentrations of DK-50 developer. Microdensitometric traces will be made and the MTF of each trace calculated. Granularity measurements will be made to compare with the MTF variations.

Objectives

Objectives of the project are to measure the differences in the MTF of the film as the function of sulfite and bromide concentrations of the developer and to correlate granularity with the MTF of the film.

Experimental procedure

1. Developer and processing

Developer used is DK-50

Each of the factors, sulfite and bromide will be at three levels of concentrations:

a. Normal for DK-50

b. Low concentration

c. High concentration

concentr. g/l	N	L	H
Sodium sulfite	30g	3g	200g
Potasium bromide	.5g	.05g	5.0g

Reasons for chosing these two factors are: sulfite is a solvent for the silver halide grains, its concentration will affect the size of the developed grains and possibly the MTF of the film. Bromide acts as a restrainer of development and is responsible for edge effects. The experiment is $2^3 = 8$ runs and a total of nine samples will be obtained. Film will be taped to the bottom of a 5 X 7 tray and brush developed. Spatial interactions (or development adjacency effects) occur in development process. These cause the peak of the MTF curve [4] to extend above 100% at low spatial frequencies. To avoid it, brush development will be used to keep adjacency effects low. Brush strokes will be one per second. Developers will be numbered one through nine and reported in this way. To obtain a uniform gamma of about

1.0 processing times were adjusted. The table shows coded developers, its concentrations and the adjusted times.

#	1	2	3	4	5	6	7	8	9
sulfite	SN	SL	SH	SN	SN	SL	SH	SH	SL
bromide	BN	BN	BN	BL	BH	BL	BH	BL	BH
develop. times in minutes	3.0	3.5	4.5	3.0	4.0	3.5	5.0	3.5	4.5

Sensitometric data

Film used: 4 X 5 Plus-X Pan (Estar base) Emulsion # HH4147

Sensitometric exposure: film plane illumination 1700 mc in Kodak 101 RIT# 2 sensitometer, at 1/5 sec. + 2.0 ND , maximum log E is .53.

Precision camera [5] was used to expose Kodak sine wave target at a reduction of 50 times. Optimum exposure was found to be 1/200 sec. + .2 ND . G. Langner [6] states that the MTF image obtained is independent of the exposure and the percent modulation of the printed on exposure.

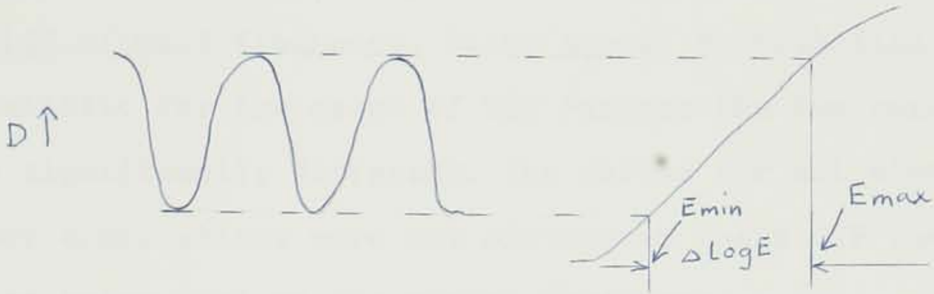
3. Microdensitometric traces

Ansco model 4 (Lent to RIT by USAF) was used to make traces. Sine wave target image traced by using: slit width .125mm/15mm optics 12.5 * 5 = 62.5 times, scanning speed .25mm/min, paper speed 8in/min.

Granularity traces of the sensitometric strip at the density level of 1.0, aperture .50mm, scan speed .25mm/min, optics 12.5*5=62.5 times magnification, paper speed 8in/min.

Due to slight variations in gammas, granularity values had to be standardized. D. Zwick[7] found a relationship between gamma and granularity. An 8% change in gamma corresponds to 6% change in rms granularity. Zwick worked with dye images but states it should hold true for silver images as well.

MTF measurements



$$\text{Modulation}_{(\text{image})} = \frac{\text{Emax} - \text{Emin}}{\text{Emax} + \text{Emin}}$$

The modulation of the target Mo is 65% so MTF $= \dfrac{\text{Mi}}{\text{Mo}}$

Results

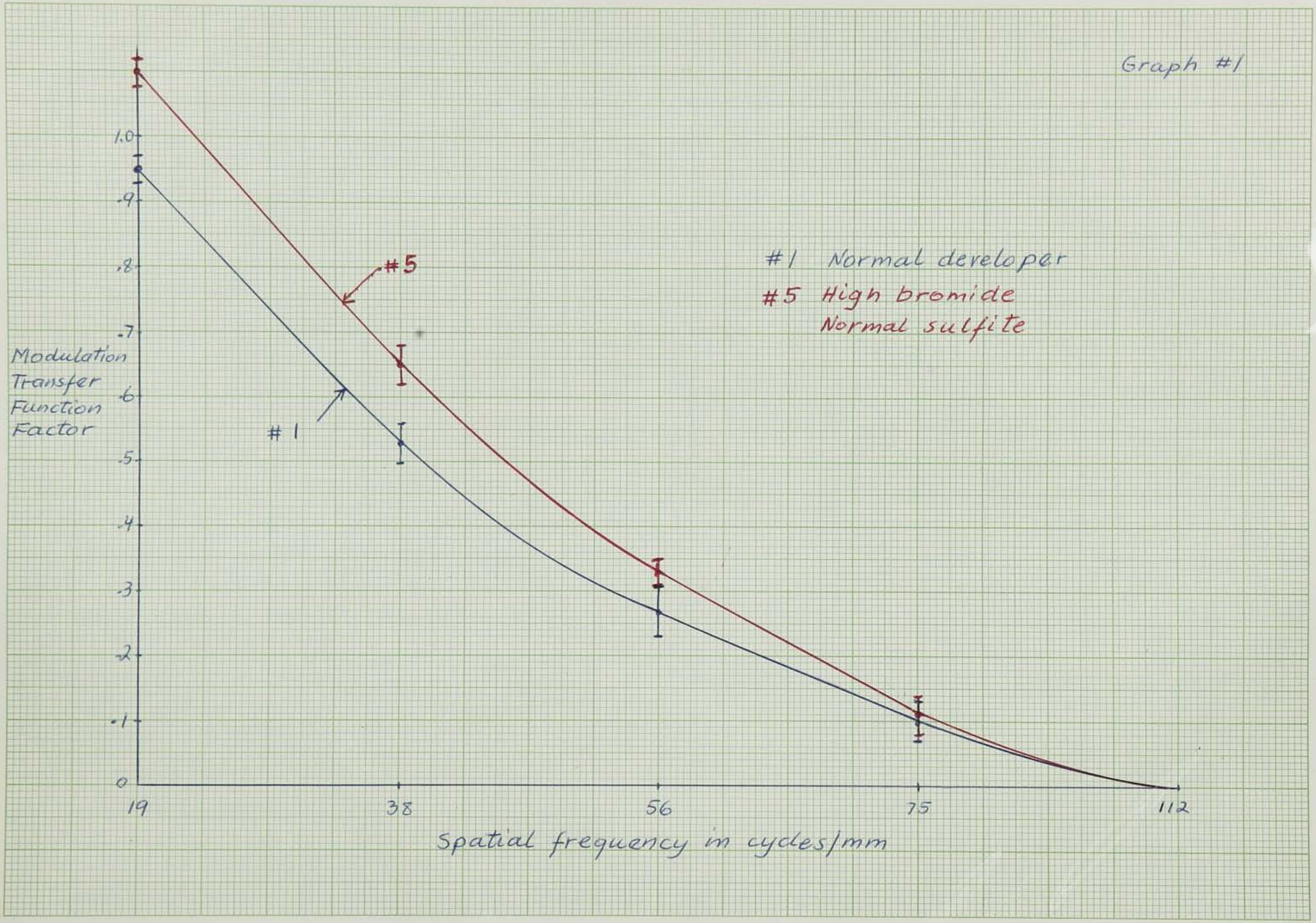
Graph # 1 shows two MTF curves and the variability of the MTF due to normal (#1) developer and (#5) developer. Each of these curves were twice replicated, an estimate of error found an 90% confidence limits put on the curves. The MTF Factor for #5 developer is above 100% modulation at the lowest (19 c/ mm.) frequency. Using normal distribution test statistic for the means of MTF Factors the two curves are significantly different. The curves for all other developer combinations were not plotted as their MTF values were below that of the normal developer.

Final gammas of the processed film

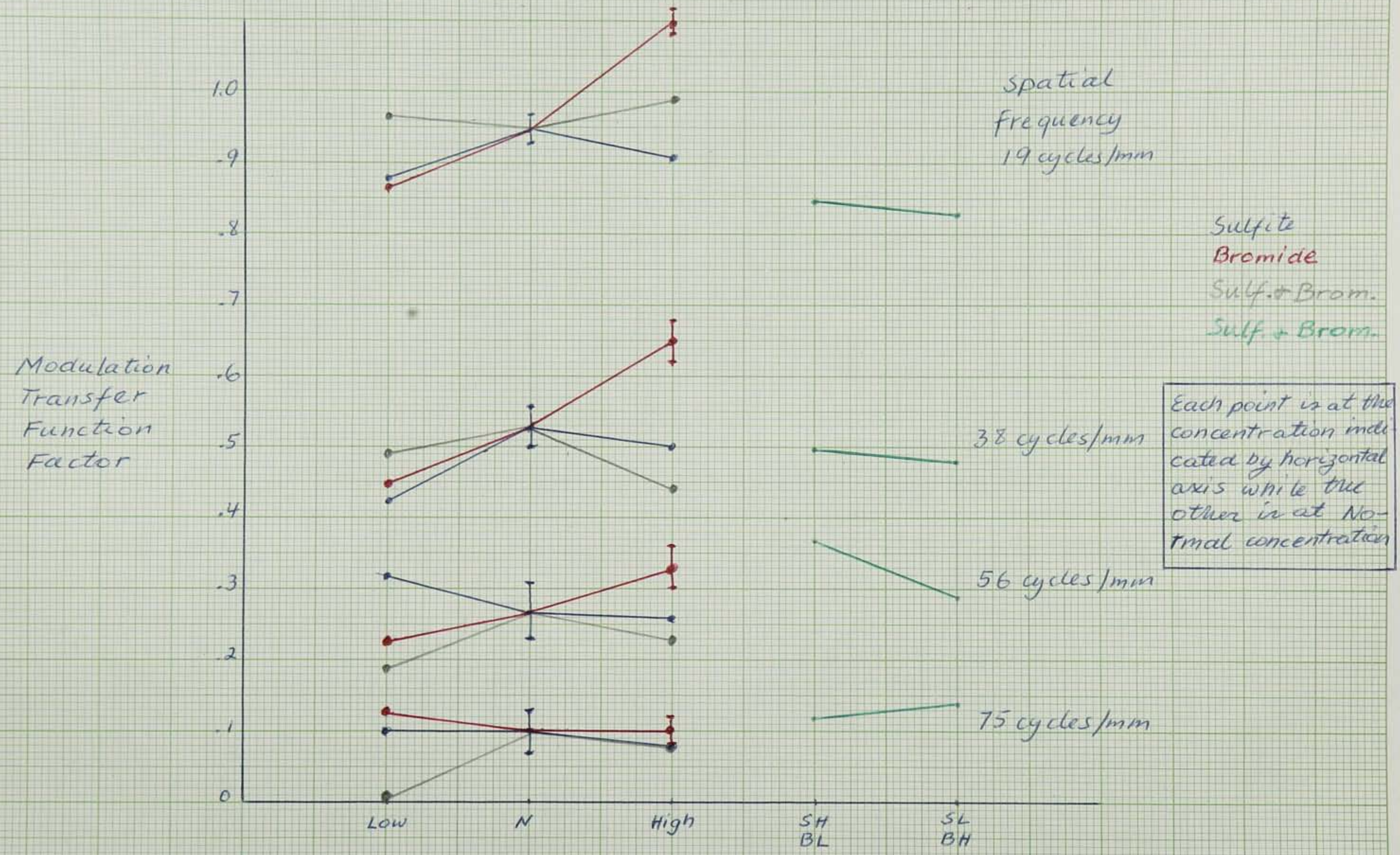
developer #	1	2	3	4	5	6	7	8	9
gamma	1.02	1.12	1.00	1.12	.92	1.10	1.20	1.28	1.10

Granularity values were computed using a Fortran program for IBM 1620 computer.

Set #	Average	Stand. dev.	G	% diff.	Stand. values
1	.9237	.09848	.28	0	.28
2	.9151	.08963	.25	7.5	.23
3	1.0775	.10312	.29	0	.29
4	1.1238	.13991	.40	7.5	.37
5	1.0690	.12302	.35	6.0	.37
6	1.0893	.15068	.43	7.5	.40
7	.9385	.10680	.30	13.5	.26
8	1.0559	.12891	.36	19.5	.29
9	.8901	.11939	.34	6.0	.32


Graph #1
#1 Normal developer
#5 High bromide
Normal sulfite
#5
#1
Modulation
Transfer
Function
Factor
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
19
38
56
75
112
Spatial frequency in cycles/mm

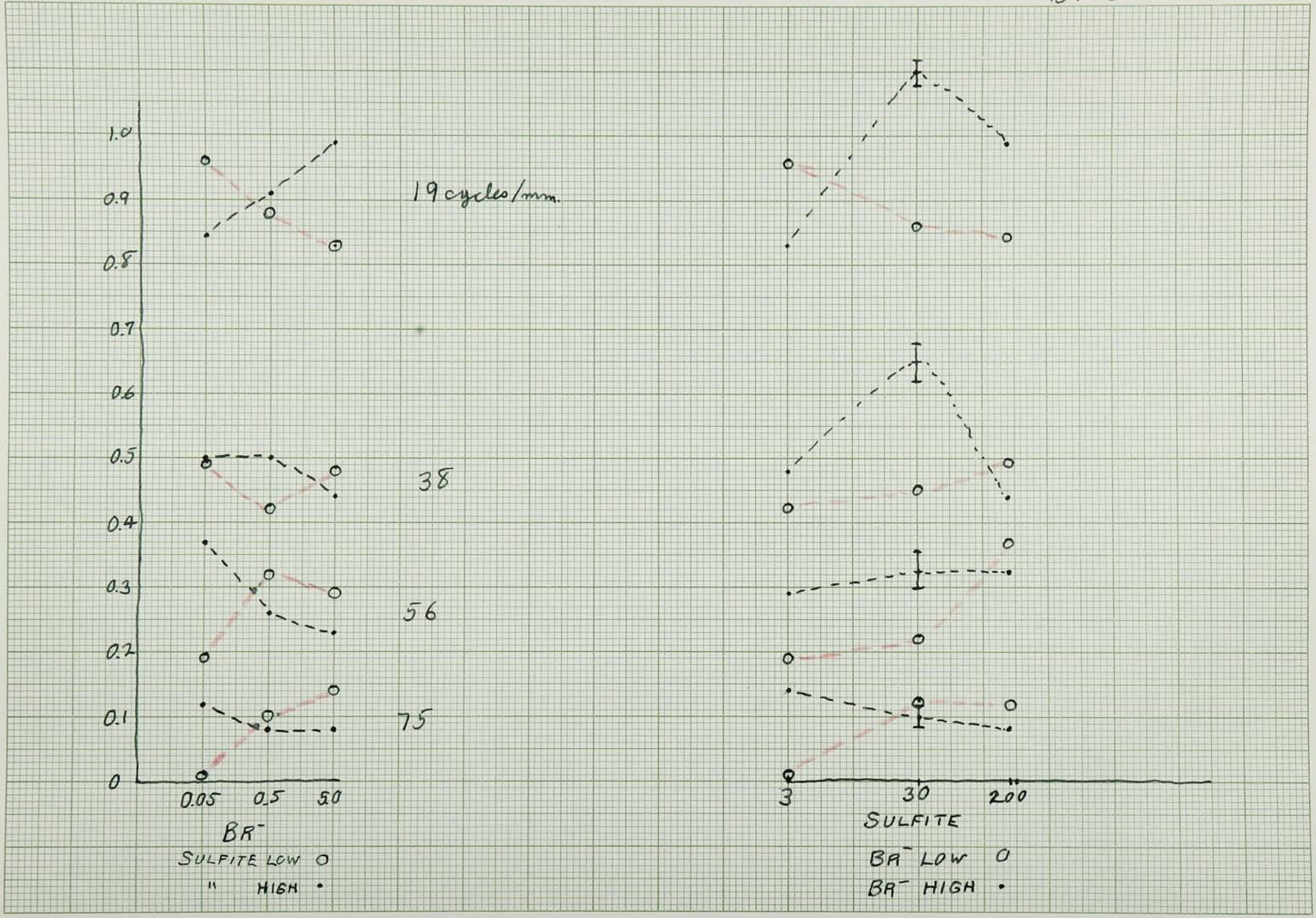
Graph #2



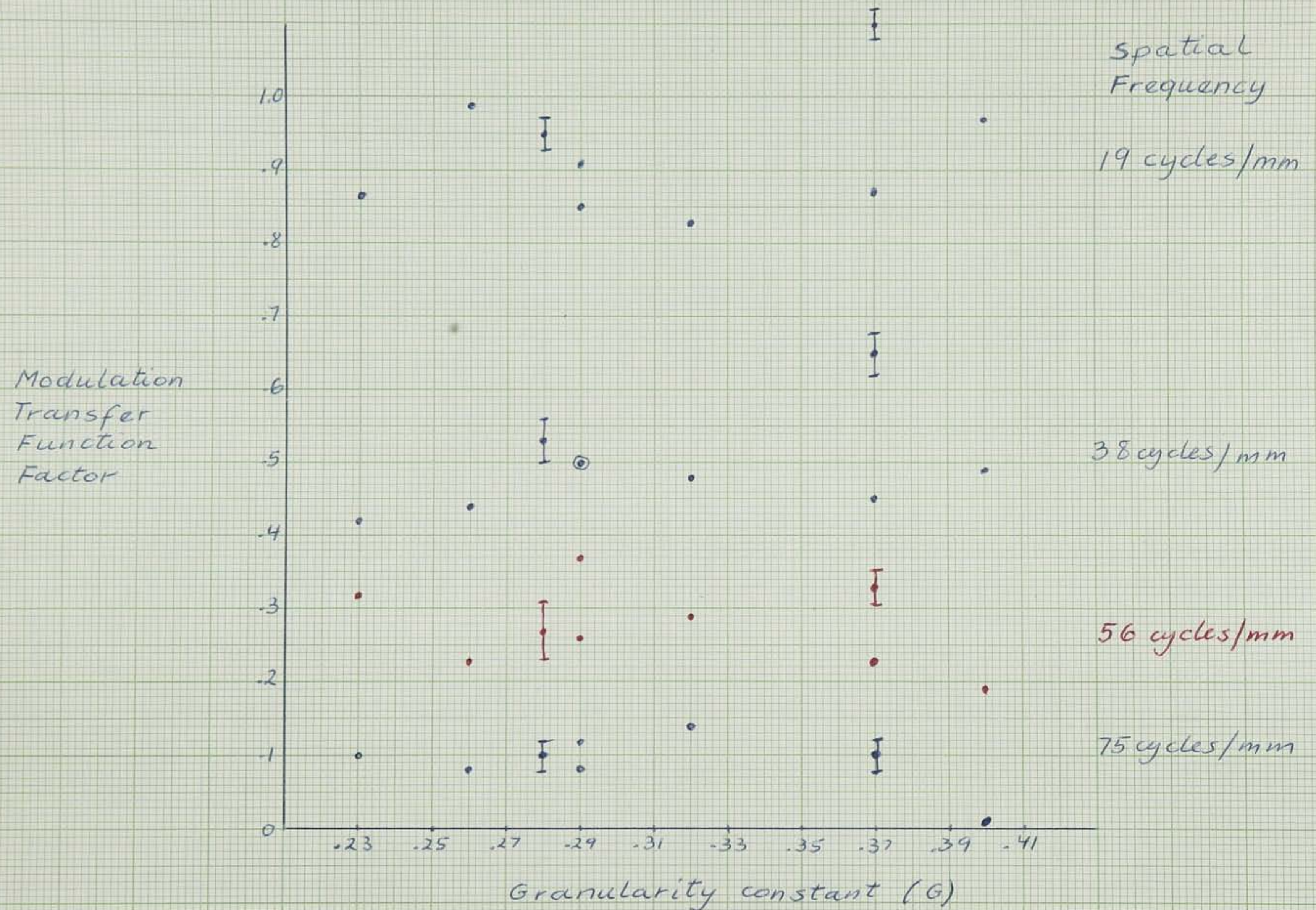
Concentration of sulfite and bromide

No correlation shown between MTF and either bromide or sulfite

B+C



Graph #3



Modulation
Transfer
Function
Factor
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.23
.25
.27
.29
.31
.33
.35
.37
.39
.41
Granularity constant (G)
Spatial
Frequency
19 cycles/mm
38 cycles/mm
56 cycles/mm
75 cycles/mm

Discussion

The results obtained are valid only for the above experiment so that no generalizations should be made. The graph # 2 of concentrations vs MTF has straight line connections between the points for clarity only. No assumptions should be made that a different concentration outside tested ones will have a value falling on this line, it may well be anywhere on the graph. An experiment with smaller increments (ex. 10g for sulfite and .1g and 1.0g for bromide) would show a better pattern of MTF dependence upon concentration. Most of the combinations of the developer does not have much effect on the MTF of the film except for one where bromide content is high and sulfite normal. Bromide in higher concentration (few grams per liter) acts as a solvent on silver halide but so does the sulfite which did not produce this change. The other explanation is that bromide causes edge effects, so this may be the case of edge enhancement which gives a higher MT Factor value but does not increase the resolving power of the film.

From the scattergram (graph # 3) of granularity vs MT Factors no conclusion can be drawn except for that not much changes in MTF as the granularity increases in the limits of this experiment. This is not a quantitative remark but on the basis of nine samples and granularity values from .23 to .40 the MT Factors do not generally increase or decrease. No correlation therefore is in place as the results do not show interdependence.

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